OBSERVATIONS ON THE ECOLOGY OF GURNARDS (PISCES TRIGLIDAE) OF THE GREEK SEAS

by

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ABSTRACT. – The ecology of gurnards was investigated from a series of collections in the Greek seas (Saronikos, Thermaikos and Pagassitikos gulf). A total of 190 operations took place every three months in the above areas between spring 1977 and winter 1978. Shining gurnard (*Aspitrigla obscura*) is the only species which was not found during our research study. Grey gurnard (*Eutrigla gurnardus*) was fished almost exclusively in Pagassitikos, yellow gurnard (*Trigla lucerna*) in Thermaikos while all the other species presented their maximum abundance in Saronikos. Large scaled gurnard (*Lepidotrigla cavillone*) was caught in large quantities in all the sampling areas, while *Lepidotrigla dieuzeidei* was found in Saronikos and Thermaikos. Abundance, length-frequency, vertical distribution data, biology of selected species (time of reproduction and recruitment, sex ratio etc) for each sampling area were analysed.

RÉSUMÉ. – L'écologie des trigles a fait l'objet de recherches à partir d'échantillons récoltés dans les mers bordant la Grèce (Golfes de Saronikos, Thermaikos et Pagassitikos). Au total 190 captures ont eu lieu tous les trois mois du printemps 1977 à l'hiver 1978. Le grondin sombre (*Aspitrigla obscura*) est la seule espèce que nous n'avons pas capturée. Le grondin gris (*Eutrigla gurnardus*) n'a été pêché que dans le Pagassitikos, le perlon (*Trigla lucerna*) dans le Thermaikos tandis que les autres espèces ont une abondance maximum dans le Saronikos. Le cavillone (*Lepidotrigla cavillone*) a été trouvé dans le Saronikos et le Thermaikos. L'abondance, la distribution de fréquence des longueurs, la distribution verticale et la biologie de certaines espèces (période de reproduction et recrutement, sex ratio, etc...) ont été analysées pour chacune des trois zones d'échantillonnage.

The gurnards or searobins are marine, demersal fishes found in all oceans. The Mediterranean gurnards were studied satisfactorily during the recent years by many workers ; Svetovidov (1936) described the taxonomic status of the Black Sea species. Priol (1932), Mouneimne (1970) and Kartas (1970) studied the biology of the species which live along the Mediterranean French coast. Papaconstantinou (1981a, 1982b) studied the biology of the species in Greek waters and described in detail the anatomy of the head and the pectoral girdle (Papaconstantinou, in press).

This study reports the results of an investigation on the vertical and geographical distribution, seasonal and annual relative abundance, time of reproduction, first maturity, recruitment etc of the gurnards in Greek seas. All these parameters are not only interrelated, but they are in direct dependence with many ecological factors such as temperature, salinity and depth. Finally, an attempt is made to examine all the above relationships statistically.

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STUDY AREA

The investigation covers three areas along the western coasts of the AegeanSea (Fig. 1) : the gulfs of Saronikos, Pagassitikos and Thermaikos.

The Gulf of Saronikos is situated in the southern part of Greece and is characterized by large depths (up to 440 m) and high salinity. The largest part of the bottom is covered by silt-sand and mud, while large areas in the SE side by detritus. The gulf is overfished (trawlers, purse seines etc.).

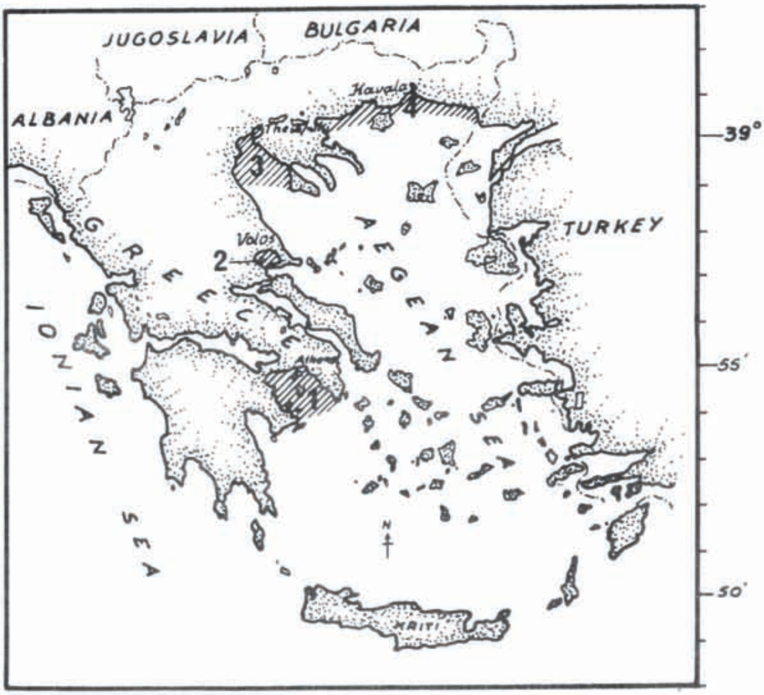

Fig. 1. – Map of the sampling areas in the Aegean Sea (1) Saronikos, (2) Pagassitikos, (3) Thermaikos and (4) Thracian Sea.

The Gulf of Pagassitikos is situated further north and is connected to the Aegean Sea via a narrow channel. The eastern section of the bay is deep (up to 90 m) and the bottom is muddy, while the western one is shallow ; the bottom is covered by Posidonia and silt-sand. Pagassitikos has been closed to trawl fishing since 1960. No rivers flow into the above two gulfs, but only seasonal streams.

The Gulf of Thermaikos lies in the NW section of the Aegean Sea. It is characterized by shallow depths (up to 90 m) and the presence of many and large rivers, which flow into the western side of the gulf, affecting the ecological conditions of large areas. The gulf is overfished (trawlers, purse seines).

MATERIALS AND METHODS

All the gurnard material which has been used in this study was fished at 61 stations in the gulfs of Saronikos (22), Thermaikos (30) and Pagassitikos (9). The samples were taken at three month intervals from spring 1977 to winter 1978, using a 400 HP engine commercial bottom trawler and a net (total length 60 m) with a cod-end mesh size of 14 mm. The duration of each trawl-haul varied between 20-45 min in Saronikos and Thermaikos and 15-20 min in Pagassitikos. The use of the same gear in all the sampling areas suggest that the catches reflect true proportional abundance. The value of a systematic sampling program of offshore biotopes is limited by various factors. In the present study, the most important is the extreme difficulty to repeat sampling exactly in the same areas ; the problems of determining the exact position at sea are well known and need no elaboration here. We are however reasonably certain that all of our samples were taken from the same general area at each station. Our certainty is based on compass headings, running time, approximate depth and visual orientation points for most stations.

The fork length (FL) of the fish was measured to the nearest mm and the weight to the nearest g. The sex was verified macroscopically for adults and microscopically for juveniles.

The salinity and temperature data for these areas (Table I) concern the water near the bottom. These values were provided by the Physical Oceanography Department of IOKAE.

TABLE I. – Maximum and minimum values of salinity in o/oo and temperature in °C from the Aegean Sea in 1977

	salinity	temperature
Saronikos gulf	38.5 - 39.0 o/oo	13.3 - 18.0°C
Pagassitikos gulf	38.0 - 38.5 o/oo	13.0 - 15.0°C
Thermaikos gulf	37.7 - 38.25 o/oo	11.8 - 15.15°C

RESULTS

Trigla lyra. Piper was fished in relatively large quantities in Saronikos Gulf (36.6 kg) and in smaller ones in Thermaikos (6.1 kg) and Pagassitikos (1.9 kg). Its relative abundance in Saronikos didn't present significant changes between spring and autumn, while a maximum appeared in winter (Fig. 2). The population at the winter season was largely characterized by the presence of specimens younger than one year (81 %). The annual fluctuation of the relative abundance in Pagassitikos and Thermaikos was difficult to study due to limited presence of the species in the gulf. The overall size range was 40-460 mm FL in Saronikos, 90-220 mm and 80-400 mm FL in Pagassitikos and Thermaikos respectively. The length-frequency distribution indicated only one major peak, located between 100-150 mm FL (Fig. 4). Its depth distribution indicated that it is a mid-slope species extending from 40 to 440 m depths (Fig. 3). The 0-group was concentrated between 80-160 m. Eighty five per

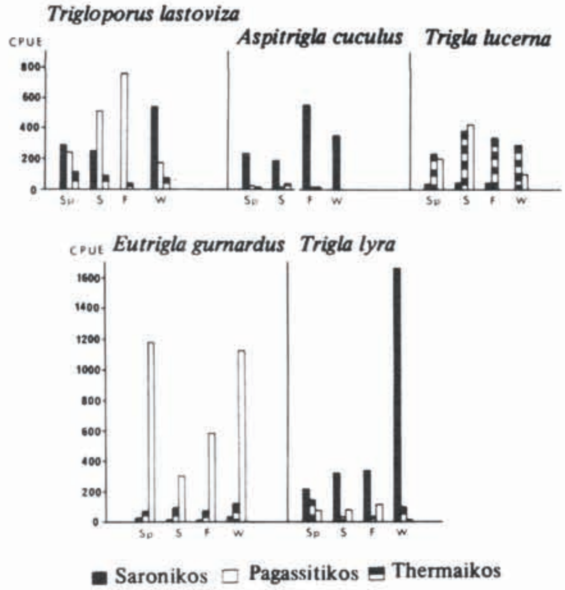

Fig. 2. – Seasonal abundance of the gurnards in the Greek seas (CPUE = catch per unit effort).

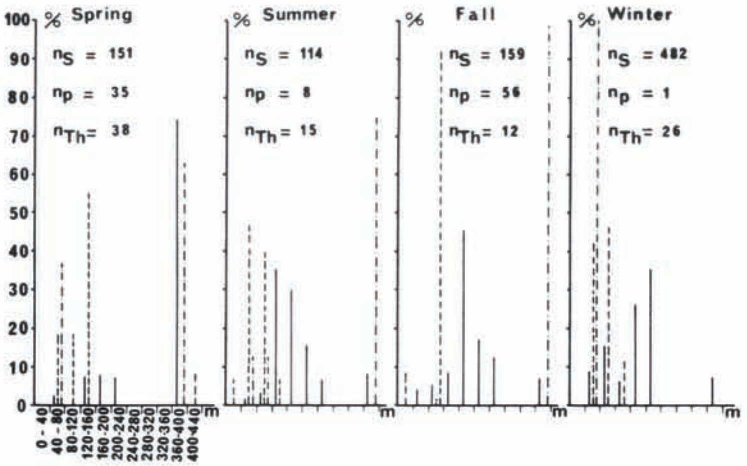

Fig. 3. – Depth-length distribution of piper in the Greek seas from spring 1977 to winter 1978 (—— Saronikos, – – – Thermaikos, –·–·– Pagassitikos).

cent of the catches in Saronikos were fished below 120 m. No size-depth dependence was evident throughout the depth range. The limited abundance of the species in the other two bays could be attributed to the fact that their depths were smaller than 110 m.

In Saronikos the recruitment takes place twice a year, at the beginning of summer and winter (Papaconstantinou 1981a). The reproduction period extends from September to March. The overall sex ratio shows a slight preponderance of males, Saronikos, 1♀:1.5♂ ; Pagassitikos, 1♀:1♂ ; Thermaikos, 1♀:1,73♂).

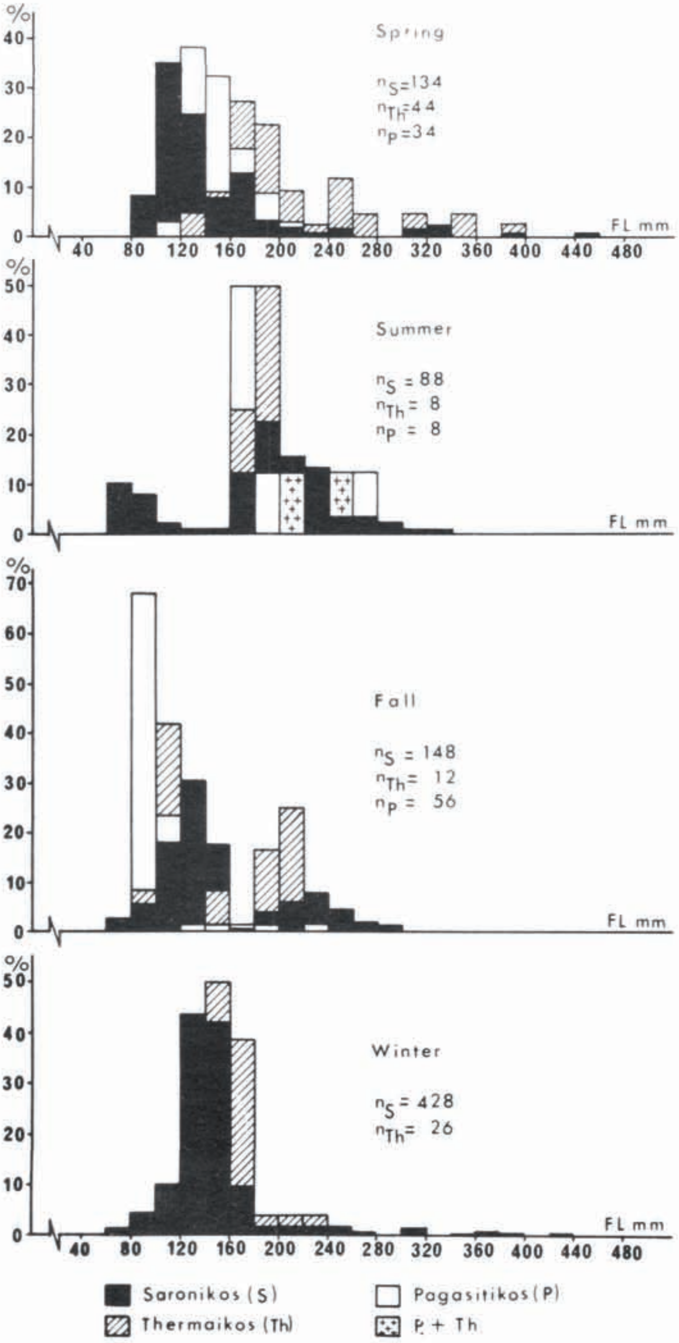

Fig. 4. – Length-frequency distribution of piper in the Greek seas from spring 1977 to winter 1978.

Trigla lucerna. Yellow gurnard was fished in relative abundance but limited number of specimens (Thermaikos 35.0 kg, Pagassitikos 5.6 kg, Saronikos 2.8 kg). It was caught mainly in spring and summer and its abundance undergoes significant reduction during the other seasons (Fig. 2). In Thermaikos the overall size range was found to be between 100-440 mm FL and occasionally 767 mm FL, while in Pa-

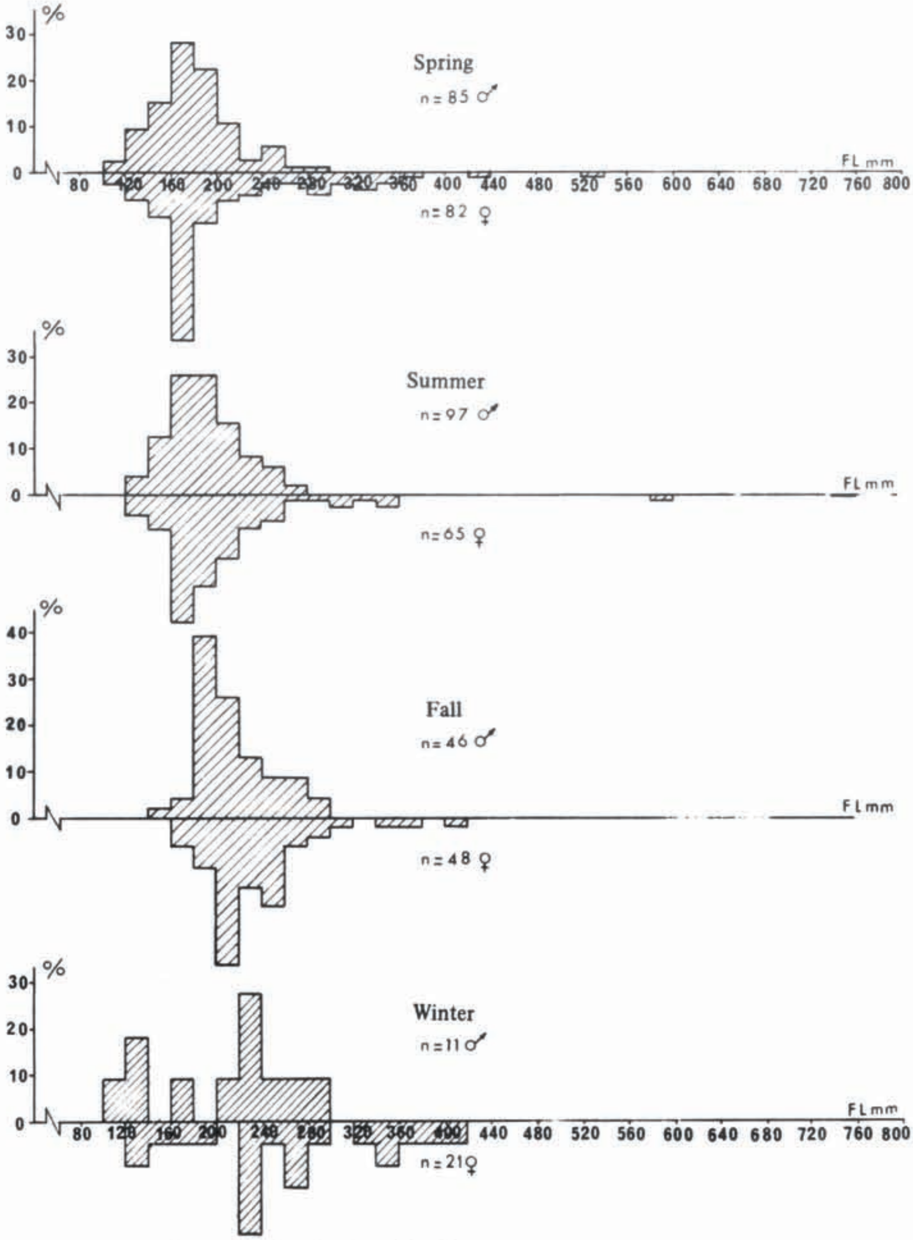

Fig. 5. – Length-frequency distribution of yellow gurnard in the Greek seas from spring 1977 to winter 1978.

gassitikos and Saronikos 163-415 mm FL and 134-327 mm FL respectively. In the last two areas only mature specimens were fished, while in Thermaikos mainly juveniles which were found near the river deltas. This fact indicates that these areas are important nursery grounds for this species and as such should require special consideration in terms of coastal zone management. A length-frequency analysis in Thermaikos Gulf indicated (Fig. 5) an abundance peak at 140-200 mm FL. These specimens were all captured near river deltas from depths of around 30 m, and low salinity, while those of more than 200 mm FL were caught deeper (detritus, Posidonia and rarely muddy or silty bottoms) at depths between 40-120 m (Fig. 6). A size-depth dependence was existent throughout the vertical distribution. The sex analysis of the specimens showed that in the 280-300 mm FL group and above the females showed a complete preponderance in the total collection over this range. It is very difficult to define the recruitment time because of the long period of reproduction, the probable concentration of juveniles ⟩ 90 mm FL in the rivers deltas and their migration to areas with higher salinity and depth. Yellow gurnard in the Greek seas reproduces all around the year and especially from autumn to spring. Fage (1918), Marinaro (1968) and Tortonese (1975), in the Mediterranean report the spring for reproduction, while Mouneimne (1970) suggest that it reproduces from February to May, off northern France. The overall sex ratio in Thermaikos was close to parity, 1.0♀:1.1♂.

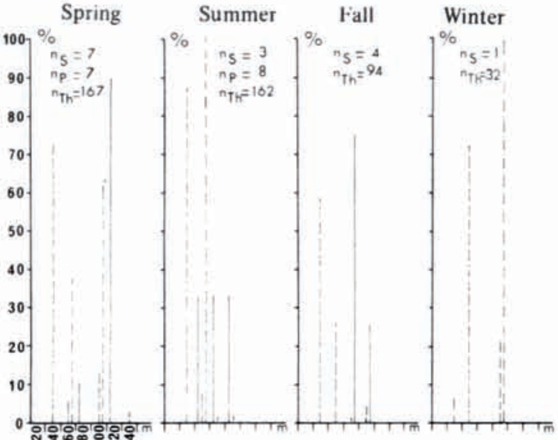

Fig. 6. – Depth of stations -length of specimens distribution of yellow gurnard in the Greek seas from spring 1977 to winter 1978.

Trigloporus lastoviza. As this is one of the more common gurnard in Greek seas, rock gurnard was represented by a great relative abundance in all sampling areas (Saronikos 41.8 kg, Pagassitikos 7.3 kg, Thermaikos 6.9 kg). In Saronikos it was fished all around the year except in autumn, while in Pagassitikos and Thermaikos it was mainly fished between spring and autumn (Fig. 2). The fork length size range was 50-300 mm in Saronikos, with a broad peak in length frequency distribution at 140-190 mm FL (Fig. 7). In the winter collection there was one more peak which

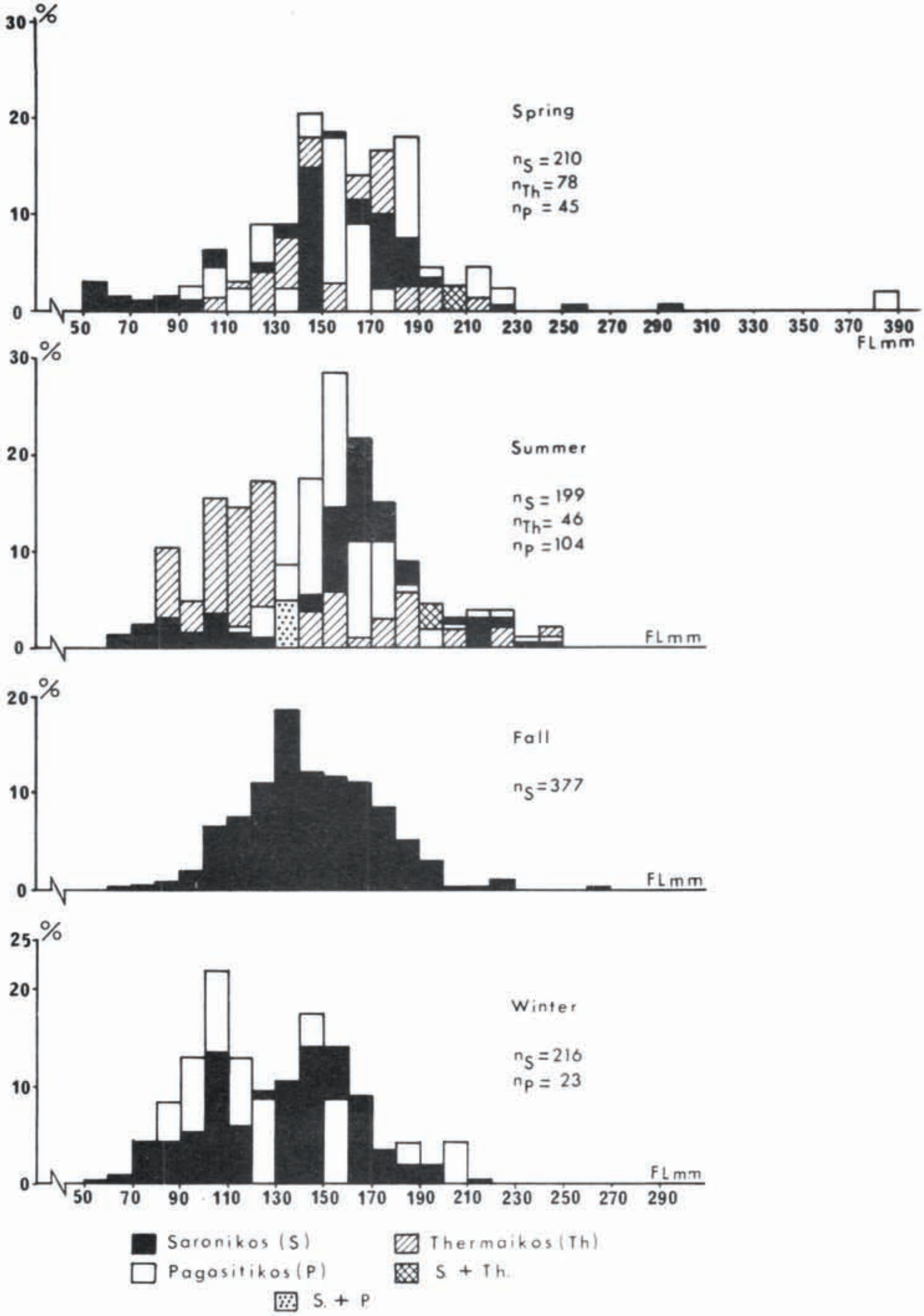

Fig. 7. — Length-frequency distribution of rock gurnard in the Greek seas from spring 1977 to winter 1978.

consisted of juveniles 70-110 mm FL. The smaller specimens in our catches in Pagassitikos and Thermaikos were 50 mm and the bigger ones 280 and 260 mm FL. All catches in Pagassitikos and Thermaikos were made within depth range 40-90 m, somewhat shallower than the 20-240 m of Saronikos (Fig. 8). The wide depth range of the rock gurnard and its adaptation to different kinds of bottoms (mud, detritus, silt-sand) made it difficult to specify the factors which affect the fluctuation of the abundance.

The recruitment begins in the spring and it seems to continue until September. The reproduction takes place from March until the beginning of July. In the W. Mediterranean, Bini (1969), Kartas (1970) and Tortonese (1975) report that the reproduction takes place in summer. The sex ratio from all the sampling areas was close to parity, Saronikos, 1♀:1.1♂; Thermaikos 1.13♀:1.0♂ ; Pagassitikos, 1.0♀: 1.42♂.

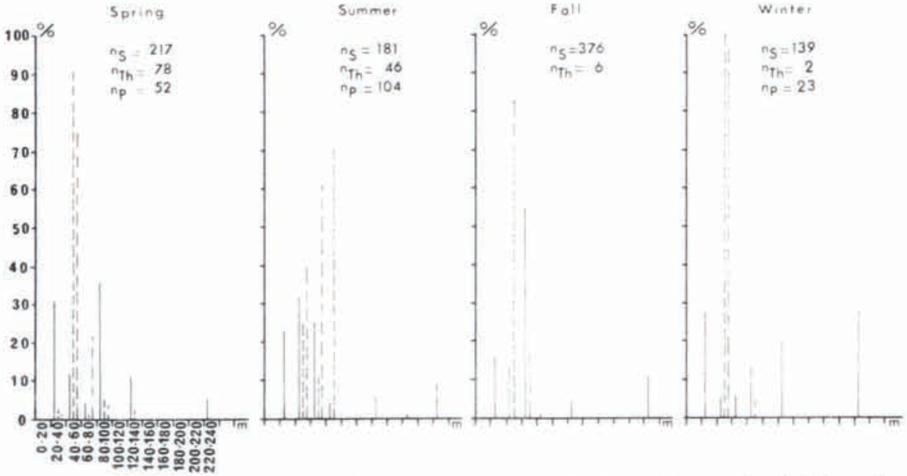

Fig. 8. – Depth-length distribution of rock gurnard in the Greek seas from spring 1977 to winter 1978.

Aspitrigla cuculus. A total of 32.1 kg of red gurnard was collected, of which 30.5 kg were caught in Saronikos, 1,3 kg in Thermaikos and 0.3 kg in Pagassitikos. In Saronikos the maximum relative abundance appeared in autumn and there after decreased gradually until the following summer (Fig. 2). The low abundance in the other two gulfs for all the year did not allow a study of the seasonal fluctuation. The overall size range was 40-240 mm FL in Saronikos and the length-frequency distribution was bimodal. A third peak occurred between 190 and 240 mm FL from summer to winter (Fig. 9). The overall size range in Pagassitikos and Thermaikos was 110-240 mm FL. Ninety five per cent of catches in Saronikos were made from muddy and silt-sandy bottoms on depths of 120-200 m (Fig. 10). No size segregation by depth was evident. The absence of the red gurnard in Pagassitikos and Thermaikos may be attributed to the shallower depth of both gulfs, which act unfavorable on growth.

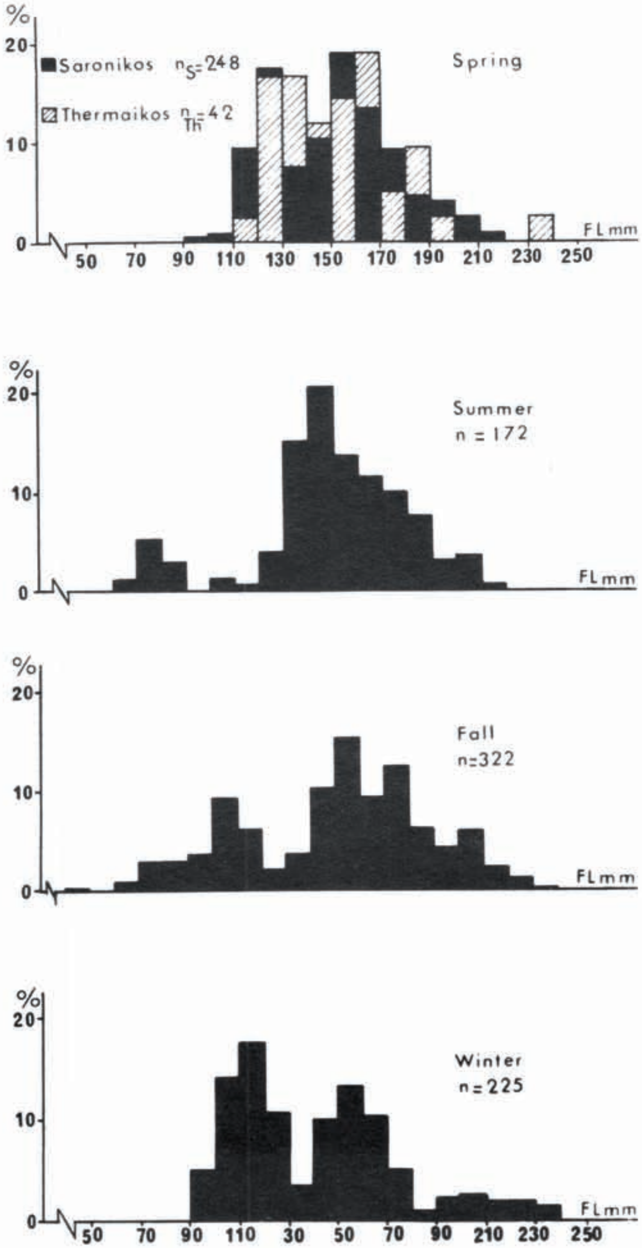

Fig. 9. – Length-frequency distribution of red gurnard in the Greek seas from spring 1977 to winter 1978.

The recruitment takes place at the end of summer or the beginning of fall. Small specimens (40 mm FL) appeared in our trawls of the mid-depth station (140-170 m) during fall. Fish from collection all over the year were examined for sexual development ; females with well-developed ova were observed from November to

June. It seems that the reproduction time differs in the Mediterranean sea ; Mouneimne (1970) reports that in the W. Mediterranean it reproduces from June to mid July, while Bini (1969) and Tortonese (1975) from April to June and January to June respectively. The sex ratio from Saronikos was close to parity, 1.1♀:1.0♂.

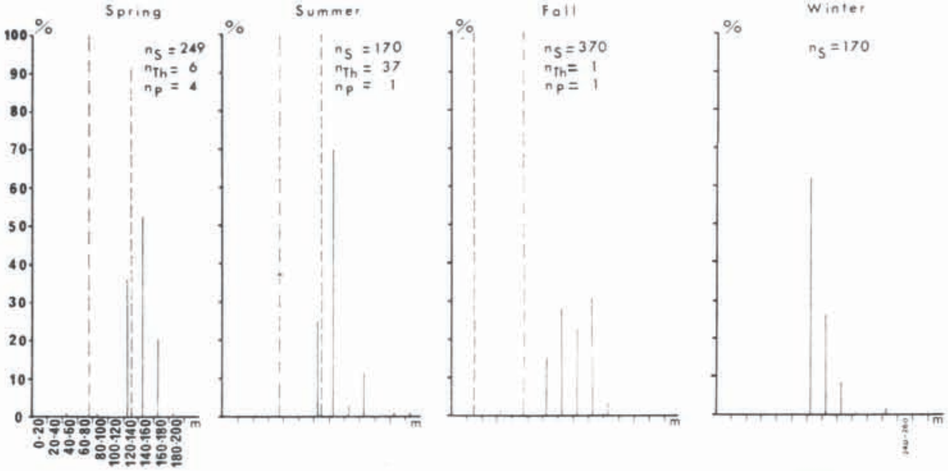

Fig. 10. – Depth-length distribution of red gurnard in the Greek seas from spring 1977 to winter 1978.

Eutrigla gurnardus. Grey gurnard was found to be widespread but not abundant in catches from Saronikos and Thermaikos gulf. It was fished almost exclusively in Pagassitikos. The relative abundance in the last bay increased from summer to the next spring with a maximum during February and March. The same seasonal distribution appeared in the other sampling areas as well, eventhough their abundance was limited (Fig. 2). The samples from Pagassitikos reported here cover the size range 80-270 mm FL, but in some cases rised up to 330 mm. Length frequency analysis suggested at least two major peaks (Fig. 11). The overall size range in Saronikos and Thermaikos was 80-240 mm FL. Females grow faster than males, but their length is not an obvious sexual character. The depth range in Pagassitikos was 40-90 m and the abundant catch came from muddy bottom (Fig. 12). The grey gurnard was also found is Saronikos and Thermaikos but at a deeper depth, 40-200 and 20-140 m respectively. In the latter two gulfs it seems that it prefers detritus bottom to silt-muddy. As it might be expected from the restricted sounding range, there was no suggestion of a size-depth relation. It is very difficult to examine all the ecological parameters which affect the geographical and depth distribution ; however the abundance in Pagassitikos may be attributable to the favorable feeding conditions during the juvenile stages.

Grey gurnard reproduces in Greek seas between February and July. Their reproductive cycle starts after the completion of the first year. Males mature before females. The sex ratio among the sexed fish showed a preponderance of females (Saronikos, 1.35♀:1.0♂, Pagassitikos, 1.55♀:1.0♂; Thermaikos 1.52♀:1.0♂.

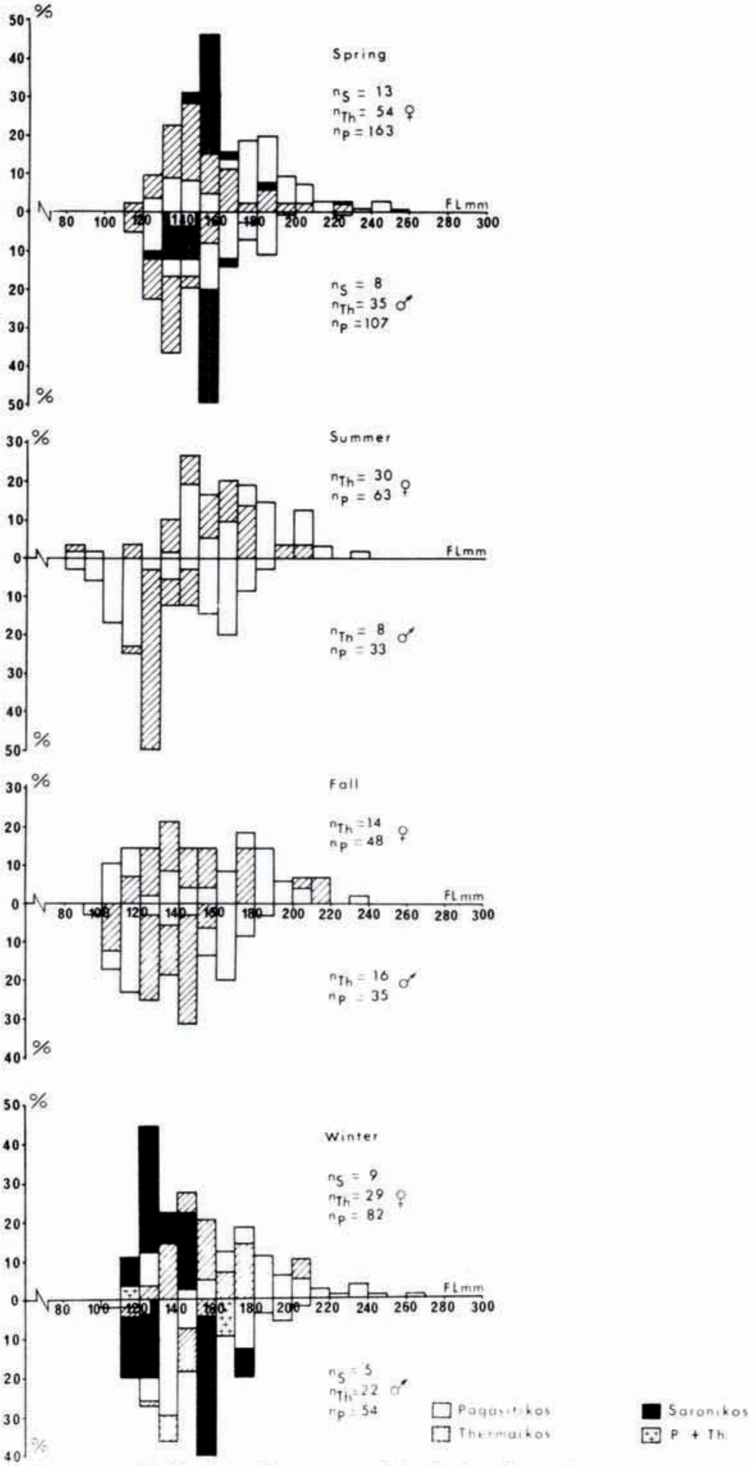

Fig. 11. — Length-frequency distribution of grey gurnard in the Greek seas from spring 1977 to winter 1978.

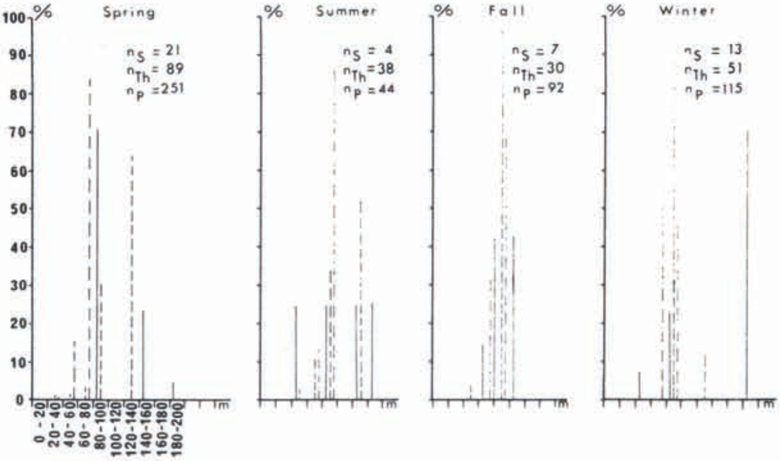

Fig. 12. – Depth-length distribution of grey gurnard in the Greek seas from spring 1977 to winter 1978.

Lepidotrigla cavillone. Large scaled gurnard was fished in large quantities in almost all the sampling stations. Its relative abundance was not counted because of the large quantities fished. Only a small, random and undefined sample size was used. The overall size range in Saronikos was 45-160 mm FL, while in Pagassitikos and Thermaikos 55-163 mm and 50-135 mm FL respectively. The length-frequency distribution indicated two major peaks in the first fishing area (45-85 mm, 100-120 mm FL), also two major peaks in the second one (95-115 mm, 115-135 mm FL) and for the third area one peak (50-80 mm) and another one (95-115mm) only in winter time (Fig. 13). The high concentration of large specimens in Pagassitikos may be due to the absence of trawl hauls in nursery grounds, and to the limited fishing mortality because the gulf has been closed to the trawl fishing since 1960. The catches were made on depths of 30-440 m ; a size-depth dependence was evident throughout this range. The immatures were concentrated on 30-40 m in depth, on a Posidonia bottom ; the mature fish were caught down to 440 m on all types of bottom. From the present results it's concluded that the abundance was maximum on 60-200 m depth.

The reproduction time is extended and varies among the sampling areas. It becomessmaller from north to south. Thus in Thermaikos a lot of mature specimens are found in February, while in the other two gulfs they first appear in March. The reproduction extends until September, but some mature specimens are found, especially in Thermaikos, until November. The recruitment (40-50 mm FL) in Saronikos takes place in summer and in Thermaikos (50-60 mm FL) at the end of winter. It's very difficult to define the exact time of recruitment because of the extended reproduction period which covers almost all the year.

Lepidotrigla dieuzeidei was fished in small quantities in Saronikos and Thermaikos gulf. Its biology and ecological preferences is very close to large scaled gurnard. It has been reported for the first time in the eastern Mediterranean by Papaconstantinou and Tsimenidis (1979) and Papaconstantinou and Tortonese (1980).

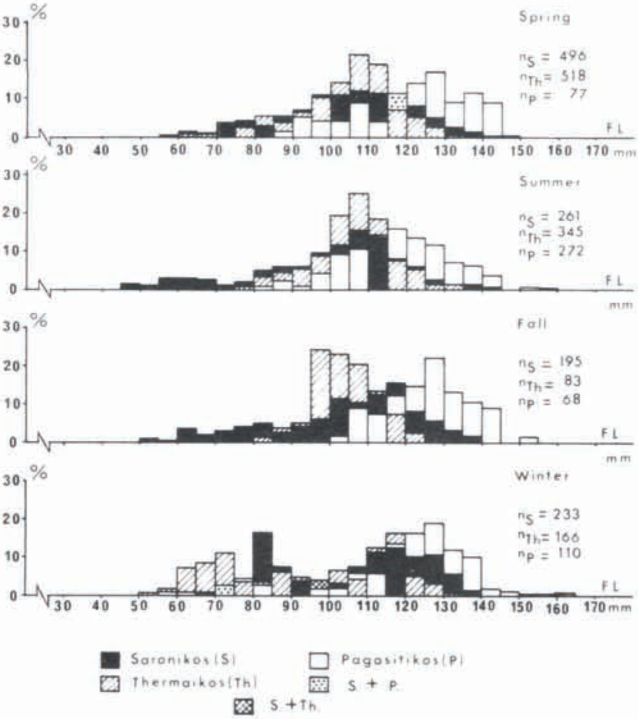

Fig. 13. – Length-frequency distribution of large scaled gurnard in the Greek seas from spring 1977 to winter 1978.

ANALYSIS OF ABUNDANCE. The abundance of the gurnards in the Greek seas which is expressed with the number of species or the number of specimens, and the total weight per collection, was analyzed by season and sampling location. Analysis of variance was employed for each of the three dependent variables in testing the null hypothesis that the effects of sampling location (Saronikos, Thermaikos, Pagassitikos), season (spring, summer, fall, winter) and interaction between sampling location and season is nonsignificant ($P > 0.05$).

The number of collections which were made for the various treatment combinations was :

	spring	summer	fall	winter
Saronikos	22	18	21	16
Pagassitikos	8	9	7	6
Thermaikos	21	30	19	13

One of the underlying assumptions of the analysis of variance is that of the homogeneity of variance. Each set of data was examined for correlation between treatment means and their within-treatment variances.

At the beginning the number of species per collections for the various treatment combinations were examined for correlation. Within-cell variances for the number of species per sampling location varies from 0.30 to 1.490. Bartlett's test for homogeneity of variances gave a $x^2 = 15.25$ for 11 df (not significant), allowing thus the continuation of the analysis of variance on the original data, without transformation (x= No of species per sampling collection).

Similar examinations were conducted for the number of specimens and total weight of fishes per collection. Bartlett's test was used to test the hypothesis of equal within-cell variances for both, the number of specimens and total weight of fishes per collection. The test gave: $x^2_{11\,df} = 78.9$ and $x^2_{11\,df} = 51.51$ respectively. Therefore both x^2 values were highly significant and reject the hypothesis of homogeneity. It is known (Sokal and Rohlf, 1969) that the logarithmic transformation is quite likely to remedy such situation whenever the mean is positively correlated with the variance and make the variance independant of the mean. This logarithmic transformation was applied on the number of specimens per collection and Bartlett's test was conducted to determine the homogenization of the transformed variances.

The results of Bartlett's for the X= log (No of specimens per collection +1) was $x^2_{11\,df} = 10.48$ for the within-cell variances of the transformed data. Because the last value was nonsignificant and there was not any correlation between mean and variances of the transformed data, we conducted further the analysis of variance for the transformed data [(X=log(No of specimen per collection +1)].

The logarithmic transformation was also used for the total weight of fishes per collection. Bartlett'stest gave a $x^2_{11\,df} = 10.56$ for the within-cell variances of the transformed data. This is not significant and the test analysis of variances was also conducted on the transformed data [(X= log (total weight of fishes per collection + 1)].

TABLE II. – Analysis of variance of X=No of species per collection (significant $P < 0.05$, highly significant $P < 0.01$, not significant $P > 0.05$)

source	df	SS	MS	F
subgroups	11	10.570		
location (gulfs)	2	8.890	4.450	5.028 +
season	3	.809	.270	.305 ns
location X season	6	8.871	1.479	1.673 ns
within error	178	157.300	.884	
	189	175.870		

TABLE III. – Analysis of variances of X= log (Number of specimens per collection + 1) (significant $P < 0.05$, highly significant $P < 0.01$, not significant $P > 0.05$)

source	df	SS	MS	F
subgroups	11	12.070		
location (gulfs)	2	10.005	5.000	21.097 ++
season	3	.872	.291	1.228 ns
location X season	6	1.193	.191	.840 ns
within error	178	42.122	.237	
	189	54.192		

TABLE IV. – Analysis of variances of X= log (total weight of fishes per collection + 1) (significant P ⟨ 0.05, highly significant P ⟨ 0.01, not significant P ⟩ 0.05)

source	df	SS	MS	F
subgroups	11	5.64		
location (gulfs)	2	2.50	1.25	3.47 +
season	3	.28	.09	.25 ns
location X season	6	2.86	.48	1.33 ns
within error	178	63.34	.36	
	189	68.98		

The results of the analysis of variance (Tables II, III and IV) for the number of gurnard species, the number of specimens and the total weight of fishes per collection indicate that the season effect is not significant. The nonsignificant location by season interaction indicates that the differences between the three gulfs in number of species, number of specimens and total weight of fishes per collection are the same throughout the season.

DISCUSSION

The gurnards are demersal fishes which live on muddy, silt-muddy, detritus or rocky bottoms. They are moving on the sea bed supported by the free end of the pectoral fins. Their ova and the first developmental stages are pelagic, transported by the currents.

The Mediterranean Triglidae includes 5 genera and 8 species, all of which are found in Greek waters. However *Aspitrigla obscura* is the only species which was not found during our research study, but its presence has been reported by others (Heldreich, 1878 ; Apostolidis, 1907 ; Hoffman and Jordan, 1892 ; Erchard, 1858 ; Carus, 1893 ; Belloc, 1948 ; Ontrias, 1971 ; and Kaspiris, 1973). The fact that this species was not found in our laborious and extensive research lead us to suppose that maybe some of the above authors refered to a species different from *A. obscura*. In fact the scientific name of many gurnards has only been classified recently (Blanc and Hureau, 1973).

The depth range of the gurnard didn't vary significantly between the sampling areas ; piper occured down to 460 m, and yellow gurnard shallower than 120 m. The range of 200-240 m seems to be the maximum depth for the majority of gurnards in the Greek seas (rock gurnard, red gurnard and grey gurnard).

As regards the adaptation of the gurnards on different sea bed substrates, all species show in most cases a preference to a specific type of bottom, without however excluding their presence from other biotopes. The above preference, in combination with the feeding pattern, depth distribution and their ecology, define the geographical distribution of the gurnards in the Greek seas.

Grey gurnard was found almost exclusively in Pagassitikos, yellow gurnard in Thermaikos, while all the other species seem to present their maximum abundance in Saronikos. Large scaled gurnard was the only species that could be found in large quantities in all the sampling areas on 30-440 m of depth.

There is no information about the population structure of gurnards in the Mediterranean. Mouneimne (1970) and Kartas (1970) have thoroughly studied the biology of the family in the W. Mediterranean (Catalane sea). No significant differences have been found on the ecology and biology between the latter area and the Aegean Sea. Grey and red gurnards are found in the Catalane Sea on 150 and 350 m respectively (200 and 220 m in the Aegean Sea). On the other hand, the reproduction in the Greek seas of the rock gurnard takes place from March to July and of the red gurnard from the end of summer to fall, while in the W. Mediterranean Sea in summer for both species.

The biology and distribution study of the gurnards in the Greek seas indicates that a lot of the species migrate during their growth. The low number of mature pipers (only 5 %) in the nursery grounds of Saronikos and Pagassitikos in relation to the 0-group (81 %) indicates that immature pipers migrate to deeper biotopes when they complete the first year of growth. Mouneimne (1970) refers to a similar migration of the piper in the Catalane Sea. Meek (1916) studied the migration of grey gurnard in the North Sea off the Scotch coast. Kartas (1970) considered migration to deeper waters to be very probable on the southern French coast. The migration of the species in Pagassitikos is very difficult to confirm due to the gulf's small size and small bathymetrical differences. The exclusive presence of immature yellow gurnards near the river deltas of Thermaikos (30 m) indicates that they use to migrate to greater depths with growth. Kartas (1970) reported that 90 % of the yellow gurnard population in the Catalane Sea (II, III and IV year old) occurred in depths below 50 m. The rest 8 % (I year old) was caught shallower than 50 m. No 0-group was found in the area. The juveniles of large scaled and rock gurnards occur exclusively near Posidonia bottom in depths of 30-40 m. They migrate to deeper waters with growth and concentrate on muddy, silt-sandy or detritus bottoms.

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